DOCUMENT RESUME

ED 426 412 CS 216 568

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TITLE Developing Textbooks That Teach: A Problem-Solving Model of Textbook Design.
PUB DATE 1997-06-18
NOTE 45p.; Paper presented at the Annual Meeting of Text and Academic Authors (Las Vegas, NV, June 17-19, 1997).
PUB TYPE Opinion Papers (120) -- Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Authors; Elementary Secondary Education; Higher Education; Instructional Effectiveness; Models; Planning; Problem Solving; *Textbook Preparation; *Textbooks; Vertical Organization; *Writing Processes
IDENTIFIERS Learnability Theory; *Text Factors; *Textbook Design

ABSTRACT

What are textbooks that teach? How can they help solve pedagogical problems? How can their pedagogical design be improved? These questions were used to develop a problem-solving model of textbook design. Textbooks that teach evoke learner activities designed to achieve contemporary cognitive goals. Suggestions for using textbooks to help solve contemporary pedagogical problems are hierarchical, ranging from those which require elementary to complex authoring skills. An author can use this hierarchy to guide efforts to develop a textbook that teaches. Development can further be enhanced by approaching the task as an ill-structured problem. Composing a text calls for planning to write, translating ideas into sentences, and reviewing text. During planning, an author should use goals and objectives to structure text according both to the discipline and to the learning activity in which the reader is to engage. During translating, an author should implement the writing plan reflectively rather than mechanically. During review, an author should obtain both expert appraisal of content and student feedback about learnability, prior to revision. General principles such as these are more appropriate than specific guidelines for solving the problem of "developing a textbook that teaches." (Contains 60 references, 1 table, and 3 figures.) (Author/NKA)

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ED 426 412

Developing Textbooks That Teach:
A Problem-Solving Model of Textbook Design

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CS216566

Paper presented at the meeting of Text and Academic Authors,

Las Vegas, Nevada, June 18, 1997

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Abstract

What are textbooks that teach? How can they help solve pedagogical problems? How can their pedagogical design be improved? These questions were used to develop a problem-solving model of textbook design. Textbooks that teach evoke learner activities designed to achieve contemporary cognitive goals. Suggestions for using textbooks to help solve contemporary pedagogical problems are hierarchical, ranging from those which require elementary to complex authoring skills. An author can use this hierarchy to guide efforts to develop a textbook that teaches. Development can further be enhanced by approaching the task as an ill-structured problem. Composing a text calls for planning to write, translating ideas into sentences, and reviewing text. During planning, an author should use goals and objectives to structure text according both to the discipline and to the learning activity in which the reader is to engage. During translating, an author should implement the writing plan reflectively rather than mechanically. During review, an author should obtain both expert appraisal of content and student feedback about learnability, prior to revision. General principles such as these are more appropriate than specific guidelines for solving the ill-structured problem of "developing a textbook that teaches."

Developing Textbooks That Teach:
A Problem-Solving Model of Textbook Design

Textbooks have long been considered at least partial solutions to educational problems, but they have suffered from the absence of theory. In the absence of theory, the content of textbooks is often viewed as derivative, their authors' goal is criticized as profit, and textbook authors themselves are politely characterized as "seldom the greatest thinkers of the subject" (Boorstin, 1980; Alred & Thalen, 1993). These criticisms are similar to those which have been leveled at virtually every human endeavor prior to the emergence of a discipline. The criticisms need to be responded to not by counterclaims, but by the development of a discipline of textbook design.

From where might such a discipline come? A critical first step was a short collection of essays titled Text materials in modern education (Cronbach, 1955). The focus of these essays was textbook improvement in light of a history of over-reliance upon poorly constructed materials. Progressive educators of the 1950s looked back to the laboratory education proposed by Dewey in the 1930s, and at the new principles of discovery learning then emerging, for ideas about how text materials might be improved to help students learn better.

Although a discipline of textbook design did not emerge from these essays, some specific recommendations were based on educational theory. For example, authors of text materials were advised to organize content to match the structure of a subject,

so that students could learn the pattern of inquiry specific to a discipline. As a second example, authors were advised to stimulate curiosity and communicate values through narration to supplement description. Thirdly, they were advised to facilitate application of knowledge through natural problem solving. Just a few years later, a set of similar recommendations were made by Jerome Bruner (1960) for teaching at all levels of education.

What the confluence of writing with instruction suggested was a parallel between the two activities which has yet to be fully explored. Little progress was made on textbook theory over the next quarter of a century (Walker, 1980), and only comparatively recently has research on textbooks begun to accelerate (Woodward, 1988). What are textbooks that teach? How can they help solve pedagogical problems? How can their pedagogical design be improved? Such questions structure a disciplined inquiry into textbook design which can result in a model, if not a theory. I believe that this model of design has the potential to improve textbooks by helping authors to become more aware of textbook composition as a problem-solving process that parallels instruction.

What are Textbooks that Teach?

Developing textbooks that teach begins with understanding what they are, and what they are not. Let's begin with some historical examples. If we ask, "what are textbooks that taught?" from the time of the Roman Emperor Constantine until the Renaissance, we discover books suited to memorization. One of the

most popular textbooks during this time was the Ars minor (or Lesser study) by Aelius Donatus, composed in the fourth century A. D. (Chase, 1929). Donatus' textbook was a Latin grammar for children, and grammar rules were presented in an innovative question-and-answer format (see Figure 1). Latin grammar was learned through a verbal interaction between teacher and student that resembled a catechism.

Today, we would find this form of interaction to be wooden, but in the fourth century, it represented a highly innovative strategy to achieve contemporary pedagogical goals. Donatus contributed very little to the theory of grammar, but his contribution to pedagogy was unsurpassed (Hovdhaugen, 1995). His introductory Latin textbook was widely imitated and in use for over a thousand years--very possibly an all-time record.

If we ask, "what are textbooks that taught?" beginning in the Renaissance, we discover a different answer--books that emphasized knowledge derived from sensory experience. Perhaps the most innovative and effective Latin grammar of the Renaissance was the Orbis pictus (or Picture of the world) written by John Amos Comenius (1728/1887) in the seventeenth century. Composed for younger or less literate children, it featured illustrations of Latin words grouped by theme and woven into sentences (see Figure 2). Latin sentences were translated into the vernacular language in a parallel column, so that students could learn something of the meaning not only of Latin term, but of its translation into their own language, from looking at the picture.

It too was enormously popular, remaining in print for over 200 years.

If we ask, "what were textbooks that taught?" as recently as the mid-1980s, we discover a yet different answer: textbooks that improved reading comprehension. Instructional design, a new branch of educational psychology, found that some text features, such as questions inserted before, within or after text, helped focus reader attention and improved reading comprehension (Lindner & Rickards, 1985; Friedman & Rickards, 1981). Further, research on reading comprehension (e.g., Kantor, Anderson & Armbruster, 1983) defined "considerate text" as that which was structured well enough to communicate information, coherent enough to develop understanding, unified enough to exclude irrelevant or distracting information, and appropriate to the knowledge base of the reader. Some of the features to increase reading comprehension (such as the insertion of questions) were readily adopted in textbooks, while other features remained more elusive.

If we ask "what are texts that teach?" today, we might find an answer that focuses less on reading comprehension than on higher-order activities of the learner. The cause of the shift in emphasis away from reading comprehension was the development of higher-order thinking skills as a priority of education beginning in the mid-1980s. Higher-order thinking includes intellectual skills--such as analysis, synthesis, and evaluation--which represent more complex skills than comprehension (e.g., Bloom,

1956). In the mid-1980s, textbooks which did not facilitate higher-order thinking became the subject of widespread criticism (e.g., National Commission on Excellence in Education, 1983; Nicely, 1985). Subsequent improvements in textbooks were often related to pedagogy to develop higher-order thinking (e.g., Chandler & Brosnan, 1994; Risner, Nicholson & Webb, 1996). Text materials that teach today need to facilitate higher-order thinking to be congruent with contemporary educational goals.

This brief review suggests that "textbooks that teach" are books which evoke learner activities designed to achieve contemporary cognitive goals. This definition would include textbooks by Donatus and Comenius, because both the Ars minor and the Orbis pictus appear to have evoked learner activities designed to achieve cognitive goals of their time. This definition would also include any textbooks in the 1980s which evoked learner activities related to reading comprehension. Finally, this definition would include textbooks developed since the mid-1980s which evoke higher-order thinking skills of the reader.

The word that Rothkopf (1970) coined to describe learner activities in the service of educational outcomes was mathemagenic, after the Greek roots for learning and to be born. Mathemagenic activities are not limited to activities which improve text comprehension, but in theory, may be designed to achieve any specific instructional objective. Textbooks that teach do so by evoking mathemagenic activities in the context of

broad cognitive goals defined by society.

This definition of "textbooks that teach" would exclude instructional materials that exhibit little if any pedagogical design, such as documents of historical importance or works of fiction. These materials may be used in the context of an appropriate learning activity, but in themselves, they are not designed to achieve contemporary cognitive goals. This definition would also exclude instructional materials that are composed primarily of procedures, such as procedural manuals or activity books. Textbooks that teach may include procedures, but these procedures are ultimately subordinate to broader cognitive goals. Textbooks that teach help students attain cognitive goals through cognitive activities.

Finally, this definition of "textbooks that teach" reminds us that such works are written and adopted as solutions to educational problems situated in a given time and place. The educational problems that textbooks can help resolve are profoundly influenced by the social milieu (Bierstedt, 1955). The problems can be reduced to a word or phrase, such as "memorization," "experiential knowledge," "comprehension," or "higher-order thinking," but these terms each represent a problem framed in the context of cultural and pedagogical values, not to mention physical and intellectual resources. Failure to take into account the milieu or context for textbook design results in a textbook that could teach, but will not teach, because it is not perceived as a useful means to achieve contemporary goals.

How Can Textbooks Help Solve Pedagogical Problems?

We all know that there is an uncertain relationship between what a textbook contains and what is taught in the classroom. By nature, this relationship seems to depend upon a number of contextual variables. Among these variables appear to be the degree of structure in the subject matter, the experience of the teacher, and the match between the goals of the textbook author(s) and those of the classroom teacher and students.

Although case studies suggest that recommendations for textbook use might be derived from correlating these contextual variables with student achievement (Ball & Feiman-Nemser, 1988; Stodolsky, 1989), no research of this type as yet exists. Existing research is limited to case study of classrooms. The most that can be said on the basis of existing research is that some textbooks appear to help some teachers achieve some pedagogical goals.

Not all educators believe that textbooks can help develop higher-order thinking in students. Some educators view textbooks as a conservative influence, inhibiting both curriculum developers and teachers in their efforts to reform curricula or redesign lesson plans to develop high-order thinking (e.g., Apple & Jungch, 1990; Ben-Peretz, 1990; Joyce & Calhoun, 1996). In their view, textbooks constrain the selection of teaching goals because they develop recall, comprehension, or application of information. These designs are perceived to foster traditional classroom activities, such as lecture, demonstration, recitation,

and seatwork. The goal of these critics is to remove the constraining influence on planning by removing textbooks from the planning process. The removal of this constraint is perceived to free curriculum developers and teachers to develop goals and activities aimed at higher-order thinking.

Other educators believe that textbooks could help teachers attain the goal of developing higher-order thinking skills, if teachers were trained to use them properly (Sternberg & Martin, 1988; Young, 1990). Advocates of this position believe that training teachers to think, and to use existing textbooks thoughtfully, is prerequisite to developing higher-order thinking skills in students. They believe that textbooks which contain exercises to teach thinking are available, but either are not preferred by most teachers, or are not used to develop thinking skills.

Still other educators agree that textbooks can help teachers attain the goal of developing higher-order thinking skills, but they believe the means to achieve this goal lies in improving textbooks. These educators are continuing to call for significant changes, even after textbook revisions in the late 1980s and early 1990s (e.g., Lumpe & Beck, 1996). They accept textbooks for their potential as sources of information, but beyond the acceptance of the text as an information source, there is little agreement over further improvements.

Suggestions for designing textbooks to teach thinking appear to exist in a hierarchy, based on increasing complexity of

authoring skills (see Figure 3). Elementary authoring skills result in the production of comprehensible text and are generally expected of text authors. Intermediate authoring skills result in the development of pedagogy, but are not always expected of text authors. (The pedagogy may be the responsibility of an instructional designer.) Complex authoring skills involve the development of authoring environments, and are not generally expected of text authors operating alone. In this section, I want to survey authoring skills to begin to explore the role of problem-solving in the design process.

Elementary authoring skills

Some reformers have argued for a minimalist approach to textbook improvement, in which textbooks would be largely stripped of pedagogy and used by students to exercise problem-solving skills taught apart from the text. The author's goal is to produce text that is accurate, current, unbiased, and considerate (e.g., Ornstein, 1994; Osborn, Jones & Stein, 1985). Considerate text, as you recall, is that which is well-structured, coherent, unified, and learner appropriate. Achieving the goal of producing considerate text requires elementary authoring skills such as organizing information, developing ideas in logical relation to each other and in relation to the whole, and understanding learner characteristics. Considerate text is often regarded as fundamental to student learning, but it must be supplemented by classroom instruction to direct students toward higher-order thinking (Honebein, Duffy & Fishman, 1993; Jonassen,

1985).

A "self-conscious" variation of considerate text would add instruction in study skills beginning with the introduction of the textbook. The text would not only exhibit the virtues of considerate text, but it would begin with an explanation of the author's goals, a description of the text structure, and suggestions for a study strategy including "higher-order" questions (Anderson & Armbruster, 1985; Pace, 1985). The pedagogy of the text would provide both examples of higher-order questions, and reminders to students to formulate them. In this approach, the text, as much as the teacher, would help the student set and achieve learning goals.

Intermediate authoring skills

Still other suggestions to develop student thinking call for more complex authoring skills. Some of these designs involve innovations in print pedagogy to develop the type of thinking pertinent to both the learning context and a reformed curriculum. In this approach, pedagogical innovations help the teacher achieve curriculum goals derived from contemporary content standards (Ball & Cohen, 1996). Curriculum goals include higher-order thinking skills relevant to the subject being taught. To help teach such skills, the textbook pedagogy is designed by authors and publishers to enact curricula. Enactment of curricula requires authors not only to be knowledgeable of relevant learning activities, but to adapt them for presentation in a textbook or related instructional materials. This task is complex

enough that some distance educators have argued for the separate development of textbook pedagogy by an instructional designer (e.g., Carter, 1985). Whether developed by a content specialist or an instructional designer, pedagogy should include enough options for exercises and activities to respond both to the learning context and to activity preferences of the teacher.

Somewhat more complex designs use computerized pedagogy to promote higher-order thinking (e.g., Bettex, 1995; Deloughry, 1996; Whalley, 1993). The activities themselves may be little different from those ascribed to traditional textbook pedagogy or associated with ancillaries, but they are presented through an electronic medium. Electronic pedagogy ranges from that which provides only supplementary information (e.g., easy and rapid access to additional information, illustrations, or documents) to that which engages thinking more actively (e.g., involvement in problem-solving exercises or simulations). Computerized pedagogy requires skills associated with authoring hypertext or multimedia. Although relatively simple authoring tools (such as Apple's HyperCard or IBM's LinkWay) exist, their use to develop higher-order thinking in students can require sophisticated programming skills.

Complex authoring skills

Radical advocates of design reform argue for student use of authoring capabilities to develop their own textbooks (e.g., Cunningham, Duffy & Knuth, 1993). The student authors' goal is to construct comprehensible text, sometimes including material or

illustrations from other sources. The result might be a personal handbook to accompany a standard textbook or a even a personalized textbook. Because the approach to authoring paper or electronic text requires students to develop authoring skills, instructional support or guidance is required (Hammond, 1993). The relationship between the teacher-author and student-author is sometimes characterized as an apprenticeship. Support or guidance may be provided through interaction with the teacher, more experienced students, or both. Such interactions in combination with authoring activities purportedly develop higher-order thinking. Skills involved in structuring authoring environments involve expertise in both teaching and the use of authoring tools.

This observation returns us to a position close to the beginning of the discussion. Researchers have not defined a unique role for textbooks in solving pedagogical problems, but proposals for what that role should be abound, ranging from suggestions that require elementary authoring skills to those that involve very complex authoring skills. These suggestions are not mutually exclusive, but represent a set of goals in a hierarchical relationship to each other. One obvious implication of this hierarchy is that elementary authoring skills are also the most fundamental--they represent the sine qua non of developing textbooks that teach. The text must be accurate and considerate to teach, whatever the design of the classroom teacher.

The hierarchy of authoring skills also represents a sequence in the design of textbooks to teach thinking. Assuming an accurate and unbiased knowledge base, text authors can begin with the goal of producing considerate text. The development of "self-consciousness" in the introduction and text can occur later. Development of pedagogy to attain the goal of higher-order thinking can occur next, and the use of electronic authoring skills--by the teacher-author or the student author--can occur last. Although there is no one way to develop textbooks that teach thinking, the result of following this design sequence would be a textbook "layered" to teach thinking in a rather comprehensive way.

Finally, this hierarchy of authoring skills suggests that developing textbooks that teach is still an "ill-structured" problem, or one in which relatively few of constraints, goals, or solution procedures are specified beforehand. Developing textbooks to teach higher-order thinking skills is not a process of imitating successful textbooks of the past in their content or even their form. Rather, it is a creative endeavor in which constraints, goals, and solution procedures need to be newly defined by authors and publishers during the planning and development of each textbook project.

How Can the Pedagogical Design of Textbooks Be Improved?

For a textbook to be effective, it must be written by an author who can think like a teacher. Since the 1980s, both nonfiction writing and teaching have been analyzed in terms of

problem-solving processes, but these analyses have never been fully coordinated. Their coordination presents possibilities for improving the pedagogical design of textbooks, because it can help writers to think more like teachers who solve pedagogical problems.

Models of problem solving in writing (Hayes & Flower, 1980, 1983, 1986) and instruction (e.g., Popham & Baker, 1971; Dick & Carey, 1996) are similar, but not the same. Their similarity is due to three assumptions. First, they both assume that activities which they describe are goal-directed. The goal in nonfiction writing is often expressed as the writer's purpose. The goal in teaching is often expressed as an instructional goal, which is particularized in terms of student educational objectives. Second, both models assume that a problem is defined as a goal that someone wants to attain but does not immediately know how to achieve (Newell & Simon, 1972). If someone were to know how to achieve a goal, it would not represent a problem. Third, models of problem solving in writing and teaching describe similar processes.

Viewing the models side by side, rather than in the form of a flowchart, highlights the parallels between processes (see Table 1). Planning the composition corresponds to setting goals, writing objectives, and developing strategies in teaching. Translating material from memory into written sentences corresponds to implementing the teaching strategies. Reviewing what has been written corresponds to evaluating the strategies in

light of the objectives. These parallels suggest not only similarities between models, but compatible activities for writers who are developing instructional materials.

Problem solving in planning

In the Hayes and Flower model of composition, the task environment, which consists of the writing assignment (topic, audience, and motivating cues) and produced text, lies outside core processing activities, as does the writer's long-term memory. Among the core processes, planning consists of generating content, organizing it, and setting up writing goals and procedures. Planning begins with considering the writing assignment (topic, audience, and motivational cues such as a deadline) and retrieving relevant information from long-term memory. During planning, the writing task becomes mentally represented as a dynamic set of goals that both guide and constrain the act of writing. The goals are prioritized in a hierarchy that can change during writing as goals are reconsidered and modified. The written outcome of planning is often a sketchy outline of rhetorical goals and topic "gists."

Scholars have sometimes used of the Hayes and Flower model to develop guidance for textbook authors. Orna (1985), for example, perceive purpose for a textbook author to begin with identifying characteristics of the writing task, including the use that the audience would have for information. She suggested that during planning, textbook authors develop a structure or organization for text based on audience use. Meyer (1985)

suggested that authors signal their plans to readers through text structure, even at the level of paragraph transitions. She perceived "signaling" to improve text comprehension by indicating a structure for both storage and recall.

The value of a framework or organization for text which develops out of the intended use for knowledge, and which is then signaled to the reader, cannot be overstated. Psychologists know that retrieval of information from the brain occurs most easily when the brain is in the same state it was at the time information was acquired. In other words, the writer's purpose as manifested in the organization of text must be the same as the reader's purpose in using textual information if the information is to be later recalled. Consequently, each text should be structured not only according to the discipline it represents, but according to the activities in which the reader is to engage when using information.

What can instructional design contribute to this insight? Instructional design involves a problem-solving cycle that begins with the consideration of what the problem is. Problems are broadly defined by the differences between what should be and what is (Rossett, 1987). The "shoulds" can be gathered from a number of sources including consideration of broad cultural norms and existing instructional materials as well as market surveys and curriculum objectives. The differences between "what is" and "what ought to be" generally represent needs for instruction, which may be cognitive, affective, or psychomotor. The needs for

instruction are then transformed into goals and objectives by considering constraints on learning, such as characteristics of the learner, available technologies, and other resources. One outcome of planning is a set of goals for instruction that can be particularized as student educational objectives.

These objectives, each of which begins with a verb that describes a student action, often identify learning activities (such as "develop a positive attitude toward learning to write," or "plan an experiment to develop a scale of hardness for a given set of materials"). Student educational objectives particularize learning activities that can structure text. Developing a positive attitude toward writing, for example, requires not only information about writing as a learnable skill, but willingness to learn that can be developed through reading a persuasive introduction. Planning an experiment to develop a hardness scale requires not only understanding what an experiment is, but a model experiment, and enough scaffolding in instructions to support the efforts of a student to plan his or her own experiment. The outcome of textbook composition becomes usable text, not just informative text.

The match between the structure of a text and learning activities is crucial when the goals for learning involve higher-order thinking. It is not sufficient to say that text should be considerate, that is, well-structured, coherent, unified, and learner appropriate. An author needs to particularize what these qualities mean if text is to help achieve the goal of developing

higher-order thinking.

To be considerate of thinking, text must be responsive to higher-order thinking both in the discipline and in the reader. A text that is well-structured for thinking is not simply hierarchically arranged; rather, its organization must reflect the core processes of a discipline, such as the writing process in composition, or the processes of inquiry in a particular science. A text that is coherent in thinking is not simply logical; rather, its logic must reflect patterns of thinking in the discipline, such as cause/effect in history, or problem/solution in a science (Armbruster & Anderson, 1985). A text that is unified by thinking is not simply united by a theme; rather, it presents and re-presents the questions that structure a given discipline. Finally, a text that is appropriate to the thinking of the learner does not simply have an appropriate reading level; rather, it engages the learner in higher-order thinking that is appropriate to the learner's cognitive abilities.

Similarly, an author needs to particularize what is meant by "self-conscious" text if a text is to develop higher-order thinking skills. This particularization is made easier by teaching goals which specify what the higher-order thinking skills are. A self-conscious text, for example, will differ from a considerate text in making the reader <u>aware</u> of how the text structure reflects the core processes of the discipline; how the text demonstrates patterns of thinking relevant to a discipline;

how it presents and re-presents key questions; and both names the higher-order thinking processes it engages, and explains how it engages them.

Further, instructional objectives make design of pedagogy easier, whether the pedagogy is developed in paper or electronic form. Objectives for learning a subject should suggest the type of learning activities that lead to the development of higher-order thinking in that subject. Some of these learning activities--such as individual or group inquiries, debates, simulations, and projects--can be embedded in the pedagogy.

Instructional objectives can even guide the construction of text by students. As mentioned above, constructing considerate text requires an understanding of not only the reader, but an understanding of core processes, patterns of thinking, and recurrent questions of a given discipline. Consideration of these elements of a discipline and consideration of their readers' knowledge and thinking in the course of constructing paper or electronic text can lead students to discover much about the discipline at their own (as well as others') level of understanding. Such discoveries are time consuming, but they result in the construction of an understanding which permits students to make sense of their world.

Problem solving in translating

In the Hayes and Flower model, translation involves the expression of ideas into sentences and occurs under the guidance of the writing plan. Ideas are probably not stored in long-term

memory as language but as propositions (e.g., relating concept to concept, or concept to attribute), so translation explains how propositions are transformed moment by moment into language. Research by Kaufer, Hayes and Flower (1986) demonstrated that this type of translation is not a routine skill, but is effortful and goal-directed. It represents a problem-solving at the moment of writing sentences.

What can problem solving by instructional designers contribute to this observation? The answer is that instructional designers have made some progress toward the discovery of how authors develop comprehensible text (Duffy et al., 1989). This research used "think alouds" by writers, as well as interviews, to discover the moment by moment goals and strategies experts use when they rewrite text.

What researchers found is that categorical goals of experts such as "improve structure," "develop coherence" or "increase interest" do not necessarily improve the comprehensibility of text. One experiment (Graves et al., 1988), which pitted Time-Life editors against composition teachers and text linguists in efforts to rewrite a 400-word passage from a high school history textbook, found that rewrites by Time-Life editors were twice as effective in increasing student recall as rewrites by the teachers and linguists. The changes by Time-Life editors focused on increasing interest (making passages more dramatic and personal), whereas those by composition teachers and text linguists focused on improving structure or developing coherence.

This study pointed to a motivational goal (increasing interest) as the source of improving comprehension, but attempts to replicate the results failed (Britton et al., 1989; Duffy et al., 1989). What both replication efforts found was that texts rewritten by composition teachers improve comprehensibility more, but improved composition was the result of simplifying sentence structure, not altering the structure of information.

These results suggest that what an author does to produce comprehensible text may not be replicable from author to author or even text to text. This situation makes the development of guidelines for producing comprehensible text nearly impossible. Duffy and colleagues (1989) concluded that producing comprehensible text is an ill-defined problem which requires cognitive flexibility to solve. Cognitive flexibility is developed not through following guidelines to generate text, but through studying a series of "multidimensional examples that reflect the interconnectedness of the features" (Duffy et al., 1989, p. 453) that enhance comprehension. What should develop is not a set of personal guidelines for writing, but a skill of thoughtfully implementing a writing plan, so that what is written is responsive to the needs of learners moment by moment.

The distinction between this problem-solving skill and planning skills is described in the literature on teaching as the distinction between reflection <u>in</u> action and reflection <u>on</u> action (Schon, 1983). Reflection <u>in</u> action involves spontaneously solving teaching problems as they arise. Some of these classroom

problems arise because of unexpected behavior, some because of misunderstanding information. Reflection in action requires sensitivity to moment-by-moment problems in communicating expectations and information. This skill of "thinking on your feet" probably reaches its zenith in first few years of teaching, however, and wanes as expertise develops in handling routine situations (Wakefield, 1996). Translation of ideas into comprehensible sentences may require a similar skill of "thinking on your seat" during composition--guiding the comprehension of the reader through information of uneven difficulty. "Thinking on your seat" requires a sensitivity to the audience, and understanding which information needs simplification, which needs illustration, which elaboration, and so on, to develop student comprehension of text.

Reflection in action to develop higher-order thinking skills is more problematic. Teachers who become reflective practitioners routinely inquire about causes and effects in the course of their teaching (LaBoskey, 1994). They possess curiosity. It may be that rhetorical strategies such as interrogation of the reader, rhetorical questioning, thought experiments, and expressions of wonder can model curiosity on the sentence level. It would not be surprising if an "inquiring mind" were to be manifested in an author's style as he or she writes, but it is doubtful that guidelines can be created which develop this expressive component of writing.

Problem solving in reviewing

Reviewing involves evaluating what has been planned or written. In the original Hayes and Flower (1980) model, reviewing consisted of reading and editing, but in later versions of the model (e.g., Hayes & Flower, 1983, 1986), it consisted of evaluating and editing. This change appears to have developed from the perception that only when the outcome of evaluation was negative did authors engage in editing.

Reviewing the literature on revision skills, Hayes and Flower (1986) noted that the more expert the writer, the more time was spent in revision as opposed to planning or translating. Expert writers were more attentive to global problems, and were more likely to change the meaning of what they had written, than were novice writers. Expert writers were more likely than novices to set goals for revision in light of a large portion of text, and less likely than novices to focus on individual words and phrases.

Their literature review suggests that reviewing is a problem-solving activity relatively independent of planning or translating. What triggers goal setting in evaluation is the detection of faults through either a sense of incongruity between the writer's purpose and the text produced so far, or a negative evaluation of the writing plan, or even a failure to comprehend what has been written. Detecting minor faults results in a revision strategy, whereas detection of major faults results in a rewrite strategy.

Detecting faults is easier in evaluating others' writing than in evaluating one's own, so strategies for evaluating and editing frequently involve people other than the writer. The purpose of the involvement of others is not to transfer responsibility for evaluation to others, but to increase the accuracy of the evaluation, and often to help set goals for revision or rewriting. Accuracy of evaluation generally involves two technical subgoals known as reliability and validity. In general, an adequate number of others involved in evaluation helps attain the subgoal of reliability, and careful selection of an evaluation procedure to assess the achievement of text goals helps attain the subgoal of validity.

Ironically, the research on revision by people other than the author suggests that often, while people other than the author should be involved in evaluation, the author should do the revising. In some instances, revisions by experts other than the original author have increased the comprehensibility of an original document, but in other cases, they have not (Hayes & Flower, 1986; Wright, 1985). For this reason, the original text author is frequently responsible for revising his or her own text using feedback from others including both experts of various types and students. Expert appraisals are generally most useful for content revisions, while student try-outs are useful for increasing learnability, or the ease with which students can learn from text (Britton et al., 1991; Nathenson & Henderson, 1980).

Instructional designers have contributed greatly to our understanding of how student feedback should be involved in reviewing instructional materials, including textbooks. Some of the most useful contributions have been from Nathenson and Henderson (1980), who helped develop courses for the Open University in Great Britain. Their insights were based on action research in the 1970s to evaluate and revise distance education materials prior to publication. Formative evaluation by learners could provide feedback to developers during materials development, while summative evaluation could only provide information about the characteristics of the final product to users.

Nathenson and Henderson discovered that formative evaluations using student feedback need to be planned carefully. Because of students' need for accurate content, expert appraisals of material should occur before student tryout; because of production schedules, timing of student feedback was of the essence; and because of the need to maximize the quality of student feedback, tryouts with individuals or small groups should occur before field testing. The use of a small group of students (20 to 40) for tryout was optimal because it provided qualitative feedback in sufficient quantity make reliable inferences about the material. The use of a small group similar to the ultimate users of the material allowed inferences to be valid.

With regard to data collection, Nathenson and Henderson found that performance data and process information were both

desirable. On the one hand, performance-related data could be used to determine whether instructional intents had been realized. It could be obtained from test scores or performance assessments. On the other hand, process data could be used to determine how students learned from the text. Process data could be obtained from student feedback questionnaires. Student feedback questionnaires inserted in the text were especially useful because students responded to them immediately after learning from text, and they sometimes suggested strategies for improvements.

Process data were routinely collected with respect to clarity, level, action, attitude, and time. Clarity involved questioning whether or not the presentation of the material (e.g., language, style, diagrams) was clear. Level involved asking whether students had sufficient previous experience with the material to understand it. Action involved asking learners about what they had done in response to the features or exercises. Assessing attitude involved questioning them about how they felt in response to materials or exercises. Time involved asking how long they spent studying, the single most important indication of how much they learned. In revising materials, authors either added, deleted, moved, or modified material in response to student feedback.

Of particular importance in developing higher-order thinking is the category of action: what learners do in response to materials. Evaluating what they do begins with finding out what

actions they take in response to features designed to develop higher-order thinking, either through performance samples, their response to feedback questions, or both. For example, authors need to know whether or not students use thinking skills exercises, and if they do use them, how they use them. Developers of texts that purport to teach thinking need to know whether or not the text is actually teaching thinking, and if not, how it can be revised to attain this goal.

Perhaps more than most other instructional designers, Nathenson and Henderson perceived formative evaluation to operate as a problem-solving process within a larger design cycle. This perception is consistent with a model of composition in which reviewing is both a goal-directed process and at the same time a component of a larger process of composition. The goal of reviewing is first, an accurate evaluation in light of the goals for writing, and then revision or editing to improve the text as a tool to achieve these goals. In terms of higher-order thinking, the goals of reviewing are 1) an accurate evaluation of whether or not the text teaches higher-order thinking, then 2) revision of the text as a tool to do so. Because this process is cyclical, it has no end until the text achieves its goal.

Conclusion

What I have found to be striking about all the problems solved by a writer is that researchers generally perceive them to be ill-structured. Authors and publishers are left to their own resources to define constraints, set goals, and determine

solution procedures. There is no "formula" for success, and those that are devised, from specific guidelines for authors to readability formulas, are repeatedly found by researchers to be unnecessarily constraining. Their application does not develop a text that teaches.

My argument has been that what can help develop a textbook that teaches is a general model and a set of principles, not a set of specific guidelines. This model defines what a text that teaches is, permits analysis of the different ways a text can teach, and suggests principles for textbook development--all in a general rather than a specific way. A problem-solving model of textbook design accomplishes these ends without being unnecessarily constrained by the circumstances of a particular milieu, let alone a particular case.

As an extended illustration of the usefulness of a problem-solving model of design, I have applied it to the problem of developing higher-order thinking skills. The development of higher-order thinking represents a central goal of contemporary education, but a problem-solving approach could be just as well applied to developing knowledge or even rote memorization. A problem-solving approach to text design does not require a goal of higher-order thinking, but it does require a goal.

That perhaps is its weakness. A problem-solving model does not easily account for "illogical" contributions to textbook development through imitation, trial and error, serendipity, or empathy, yet all of these exist in the real world of writing and

publishing. Nor does this problem-solving model address the economic problem of producing text profitably, or the personal problem of developing a product as part of a team (Schramm, 1955). The problem-solving model of textbook design developed here can only suggest that a knoweldge base is growing for a discipline of textbook design.

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Table 1

Problem Solving in Writing and Instruction

Writing Processes	Instructional Processes
Planning	Planning
Goal setting	Identifying goals
Gathering information	Writing objectives
Organizing content	Sequencing content
	Developing a strategy
Translating	Implementing the strategy
Reviewing	Evaluating the strategy
Evaluating	
Editing	

Figure Captions

Figure 1. Sample page from Orbis pictus.

Figure 2. Sample text from the translation of Ars minor of Donatus.

Figure 3. A hierarchy of authoring skills.

these are chastised
with a *Ferrula*. 11.
and a *Rod*, 12.

hi castigantur
Ferulâ (baculo), 11.
& *Virgâ*, 12.

The Study. XCIX. Museum.

The *Study*, 1.
is a place where a Student,
2. apart from Men,
sitteth alone,
addicted to his *Studies*,
whilst he readeth *Books*, 3.
which being within his
reach he layeth open upon a *Desk*, 4. and picketh
all the best things out of
them into his own *Manual*,
5. or marketh them in
them with a *Dash*, 6.
or a *little Star*, 7.
in the *Margent*.
Being to sit up late,

Museum, 1.
est locus ubi Studiosus, 2.
secretus ab Hominibus,
sedet solus
deditus *Studiis*,
dum lectitat *Libros*, 3.
quos penes se
& exponit super
Pluteum, 4. & excerpit
optima quæque ex illis
in *Manuale* suum, 5.
notat in illis
Liturâ, 6.
vel *Asterisco*, 7.
ad *Margiem*.
Lucubraturus,

BEST COPY AVAILABLE

Ars Minor of Donatus
Concerning the Parts of Speech

How many parts of speech are there? Eight. What? Noun, pronoun, verb, adverb, participle, conjunction, preposition, interjection.*

Concerning the Noun

What is a noun? A part of speech which signifies with the case a person or a thing specifically or generally. How many attributes has a noun? Six. What? Quality, comparison, gender, number, form, case. In what does the quality of nouns consist? It is two-fold, for either it is the name of one and is called proper, or it is the name of many and is called common. How many degrees of comparison are there? Three. What? Positive, as learned; comparative, as more learned; superlative, as most learned. What nouns are compared? Only common nouns signifying quality or quantity. . . .

*Adjectives and nouns were not distinguished at this time.

A Hierarchy of Authoring Skills

Complex authoring skills:
Apprenticing student authors

Intermediate authoring skills:
Computerizing pedagogy
Innovating print pedagogy

Elementary authoring skills:
Developing self-conscious text
Developing considerate text